TRANSPORTATION ANALYSIS SIMULATION SYSTEM (TRANSIMS)

VERSION 1.0

GETTING STARTED

April 1998

[Tab 1]

Contents

1. OVERVIEW OF TRANSIMS

The TRansportation ANalysis and SIMulation System (TRANSIMS) is sponsored by the U. S. Department of Transportation, the Environmental Protection Agency, and the U. S. Department of Energy. Los Alamos National Laboratory is leading this major effort to develop new, integrated transportation and air quality forecasting procedures necessary to satisfy the Intermodal Surface Transportation Efficiency Act and the Clean Air Act and its amendments.

The TRANSIMS Project objective is to develop a set of mutually supporting realistic simulations, models, and databases that employ advanced computational and analytical techniques to create an integrated regional transportation systems analysis environment. By applying forefront technologies and methods, TRANSIMS simulates the dynamic details that contribute to the complexity inherent in transportation issues of today and tomorrow. The integrated results from the detailed simulations will support transportation planners, engineers, and others who must address environmental pollution, energy consumption, traffic congestion, land use planning, traffic safety, intelligent vehicle effectiveness, and the transportation infrastructure effect on the quality of life, productivity, and economy.

The TRANSIMS methods track households, individuals, and vehicles and proceed through several steps to estimate travel. TRANSIMS consists of four modules: *Household and Commercial Activity Disaggregation*, *Intermodal Route Planner, Transportation Microsimulation,* and *Environmental Modeling*.

The *Household and Commercial Activity Disaggregation* module creates regional synthetic populations and activities from census and other data. It is an activity-based system. Trips are generated from these activities for individual households, residents, freight loads, and vehicles, rather than for zonal aggregations of households.

The *Intermodal Route Planner* module applies a demographically defined travel-cost decision model particular to each traveler to create trip plans (that is, the trip schedules and routes). Vehicle and mode availabilities are represented, and mode choice decisions are made during route plan generation. The method estimates latent demand (desired trips not made because of individual travel constraints), induced travel, and peak load spreading. This allows evaluation of different transportation control measures and travel demand measures on trip planning behaviors.

The *Transportation Microsimulation* module executes the generated trips on the transportation network to predict the performance of individual vehicles and the transportation system. It attempts to execute the travel itinerary of every individual in the region. For example, every passenger vehicle has a driver whose driving logic attempts to execute the trip plan, accelerates or decelerates the car, or passes as appropriate in traffic on the roadway network.

The *Environmental Modeling* module estimates motor vehicle fuel use, emissions, dispersion, transport, air chemistry, meteorology, visibility, and resultant air quality based on individual vehicle dynamics information received from the Transportation Microsimulation. The emissions model accounts for both moving and stationary vehicles. A model for local effects supplements the regional meteorological model for atmospheric circulation. The dispersion model for directly emitted contaminants handles both local- and urban-scale problems. The air chemistry model also includes dispersion, but deals with secondary pollutant production on larger scales.

The TRANSIMS approach relies extensively on interaction among the activity demand, the Intermodal Route Planner, and the Transportation Microsimulation.

The Household and Commercial Activity Disaggregation module generates household activities, activity priorities, activity locations, activity times, and mode and travel preferences and goals. The Intermodal Route Planner uses the activities, preferences, and goals to determine trip plans for individuals in the region. The Transportation Microsimulation executes the individual trip plans in a second-by-second simulation of the interaction among the travelers and the transportation system. The emergent traveler and vehicle dynamics in the Transportation Microsimulation yield system performance measures, such as time of travel, that affect how people plan their routes and travel modes to get to their activities. This travel information is fed back to the Intermodal Route Planner where some trips are replanned. Similarly, the difficulty or ease involved in traveling to a location at a given time determines whether, where, and when people do their activities. Again, microsimulation and planner information is fed back to the Household and Commercial Activity Disaggregation module to adjust household and individual activities.

The project team is developing interim operational capabilities (IOCs) to focus the development process. Each IOC emphasizes one or more of the four major TRANSIMS modules. With the collaboration of a selected Metropolitan Planning Organization, the project team completes a case study to confirm the IOC features, applicability, and readiness. This approach provides timely interaction and feedback from the TRANSIMS user community and also produces interim products, capabilities, and applications.

Because the Traffic Microsimulation is critical to the iteration process (that is, the emergent system dynamics affect how people plan their routes and activities), the project team chose to concentrate on the Transportation Microsimulation in the first IOC, IOC-1. In addition, several traffic microsimulation versions that successfully modeled traffic behavior were developed. This extensive microsimulation experience allowed the team to take the best of what had been learned to develop IOC-1. For the IOC-1 case study, the team chose to collaborate with the North Central Texas Council of Governments (Dallas-Ft. Worth metropolitan region).

In addition to the Transportation Microsimulation module, the IOC-1 release includes

- the TRANSIMS Analyst Interface (TAI);
- an Input Editor used to visualize and validate the roadway network;
- a Database Subsystem;
- representations for the network, travelers, plans, and vehicles;
- a Microsimulation Output Subsystem;
- Plan Viewer, a utility to display trip plans;
- Microsimulation Output Viewer, a utility to animate and display vehicle movements and summarized vehicle density; and

IOC-1 also includes the three infrastructure networks and the three corresponding final-iteration trip-plan sets used in the Dallas-Ft. Worth Case Study, plus several simplified networks to calibrate the microsimulation for basic car-following dynamics, lane-changing behavior, plan following, and gap acceptance when entering a traffic stream or turning against oncoming traffic.

In the case study, the project team found it necessary to iterate between a preliminary route planner and the microsimulation. The preliminary route planner and the corresponding iteration methods are not included as part of the IOC-1 release to potential users.

2. WHAT'S IN THE TRANSIMS PACKAGE?

The TRANSIMS Package consists of a User Notebook (this document) and two (2) compact disks (CDs).

2.1 TRANSIMS V1.0 CD # 1

Following are the contents of TRANSIMS CD #1:

installBinaryPlanFiles*
modifyHome*
modifyHome.lis
transims1.tar
BinaryPlans/
modifyFilePermissions*

The tar file, *transims1.tar*, contains the TRANSIMS environment except for the Binary plan files. The script "installBinaryPlanFiles" is run in order to install the files from the BinaryPlans directory into the TRANSIMS environment. The script "modifyHome" is run if the user installs in a location other than /opt/transims. The file "modifyHome.lis" is used by the "modifyHome" script and contains all of the files that are modified. The script "modifyFilePermissions" is run in order to change ownership and group of all directories and files that users need to write to or modify.

Table 1 lists the top-level directories in *transims1.tar*.

Table 1: *transims1.tar*

Directory	Description
data	Where data is located that is used by the various TRANSIMS systems.
database	Where the database tables for the Dallas-Ft. Worth and calibration networks are located. Also the location of the output specification tables that are created by the TRANSIMS Analyst Interface and used by the microsimulation.
output	Where the system administrator sets up for links to the local data disks that store the binary microsimulation output data.
source	Where the TRANSIMS systems source code is located.
sunos5.x	Where the TRANSIMS systems are compiled; bin contains the executables and lib contains the TRANSIMS libraries.

The BinaryPlans directory on the CD contains the following files:

Freeway1-plans.bin.tar.Z
Freeway3-plans.bin.tar.Z
Left1-plans.bin.tar.Z
Left2-plans.bin.tar.Z
Merge1-plans.bin.tar.Z
Merge2-plans.bin.tar.Z
nctcog-basecase-1-1-plans.bin.tar.Z
nctcog-basecase-1-2-plans.bin.tar.Z
nctcog-change1-1-1-plans.bin.tar.Z
nctcog-change2-1-1-plans.bin.tar.Z
tee-plans.bin.tar.Z

2.2 TRANSIMS V1.0 CD #2

TRANSIMS CD #2 is the 'Optional Data' CD. It contains the file "outputFileExtensions" that explains the extensions for the Microsimulation Output files.

There are four subdirectories (one for each of the Dallas-Ft. Worth Case Study runs). Each of the subdirectories contains two files: the compressed ASCII Plan Set and a tarred and compressed directory that contains subdirectories for all of the Microsimulation Output for the runs. Please refer to the Installation Information for more detail.

Following are the four subdirectories and their files:

nctcog-basecase-1-1:
MicrosimOutput.tar.Z nctcog-basecase-1-1-plans.txt.Z

nctcog-basecase-1-2:
MicrosimOutput.tar.Z nctcog-basecase-1-2-plans.txt.Z

nctcog-change1-1-1:
MicrosimOutput.tar.Z nctcog-change1-1-1-plans.txt.Z

nctcog-change2-1-1:
MicrosimOutput.tar.Z nctcog-change2-1-1-plans.txt.Z

3. SYSTEM REQUIREMENTS

TRANSIMS components have been developed and tested on Sun Microsystems hardware. The microsimulation can be run using either of two hardware configurations:

1) Multiprocessor

2) Single-CPU workstations on a local area network (LAN)

3.1 Hardware Requirements for Multiprocessor

- Ultra
- Enterprise

The multiprocessor machine must have at least two CPUs. Five CPUs are recommended to run the TRANSIMS software.

3.2 Hardware Requirements for Workstation/LAN

- Sparcstation 5
- Sparcstation 20
- Ultra

The minimum of two single-CPU workstations is sufficient to make microsimulation calibration runs. Five workstations are recommended in order to run the TRANSIMS software. All workstations must have TCP/IP network connectivity.

3.3 Operating System Requirement

- Solaris 2.5 or higher

3.4 Memory Requirements

- 250 MBytes per CPU for multiprocessor configuration
- 250 MBytes per workstation for workstation/LAN configuration

3.5 Hard Disk Requirements

1.2 Gbytes of space is required to install TRANSIMS. The TRANSIMS plan sets supplied with this release require 946 MBytes of disk space. The TRANSIMS software distribution and database require 250 MBytes of disk space.

The amount of disk space needed for microsimulation output depends on the types of data collected and the frequency of the collection that is specified for a microsimulation run. Some guidelines are given below for the Dallas-Ft. Worth Case Study and calibration runs.

For the Dallas-Ft. Worth Case Study, the following data was collected during a peak period (5:00 - 10:00 a.m.) microsimulation run:

- snapshot data on all study area links; three-minute collection interval
- summary data on all study area links; three-minute collection interval
- event data on all study area links

The case study was run with one master process and four slave processes. Each slave process needs ~300 MBytes of disk space on the machine where the slave will execute. For a multiprocessor configuration where all the slaves execute on the same machine, 1.2 Gbytes (4 x 300 MBytes) of local disk space are needed for raw binary data. For a workstation/LAN configuration, 300 MBytes of local disk space are needed on each workstation for raw binary data. The raw binary data from the microsimulation run must be post-processed into text files. An additional 300 MBytes of disk space are needed for the post-processed simulation data for each microsimulation run.

The calibration runs use one slave process. Output collection types and frequency for the calibration runs are predefined. The amount of disk space required depends on the type of calibration run that is chosen. A maximum of 600 MBytes of local disk space for raw binary data is needed on the machine where the slave will execute. An additional 350 MBytes of disk space are needed for the post-processed simulation data.

3.6 Software Requirements

- Parallel Virtual Machine (PVM) Version 3.3 (supplied in TRANSIMS distribution)
- Java Version 1.1 or higher
- xgl library (The xgl library in the Solaris distribution must be installed.)
- HOOPS run-time license

  In order to run the Microsimulation Output Viewer, the end user must purchase a run-time license from

  TechSoft America
  1301 Marina Village Parkway, Suite 300
  Alameda, CA 94501
  Contact: Ron Fritz, 510/769-2301

- Optional: ArcView 3.0

3.7 Compilation Requirements

- Rogue Wave Booch Components
- SunPRO C++ Compiler, v. 4.1

4. PVM (PARALLEL VIRTUAL MACHINE)

The TRANSIMS microsimulation is implemented as a distributed computing application utilizing the PVM (Parallel Virtual Machine) software package. PVM is available at no charge over the Internet from netlib. PVM Version 3.3.11 is being distributed with the TRANSIMS software package as a convenience to users. Note that Version 3.3.11 is not the latest version available from netlib. However, Version 3.3.11 was used for the IOC-1 case study and is known to work with the TRANSIMS package. Later versions of PVM may also work, but they have not been tested with the TRANSIMS package.

Documentation for PVM is also available from netlib.

- URL http://www.netlib.org/pvm3/book/pvm-book.html provides ordering information for *PVM: Parallel Virtual Machine - A Users' Guide and Tutorial for Networked Parallel Computing* from MIT Press.

- Another manual, *PVM 3 User's Guide and Reference Manual*, is available at URL http://www.netlib.org/pvm3/ug.ps.

Users interested in information about PVM are encouraged to obtain one or both of these documents.

PVM environment variables are set in the file $TRANSIMS_HOME/data/transims_cshrc, which is sourced at the end of every TRANSIMS user's .cshrc file.

PVM is unable to run if you have any queries in your .cshrc file. All queries must be removed before the TAI is used.

The TAI attempts to shield the user from most of the details about PVM usage. If problems occur, please see Section 3.5 in the PVM book or Section 4.2 in *PVM 3 User's Guide and Reference Manual* for a description of common startup problems.

5. JAVA

Java is available from the Web at

http://www.javasoft.com:80/products/jdk/index.html

Be sure to get the latest version, which, as of February 1998, is JDK 1.1.5 (Java Development Kit, version 1.1.5). It is also possible to install versions of JDK numbered 1.0.x. These versions are incompatible with the TRANSIMS Analysts Interface (TAI) and should not be installed.

On the above-mentioned Web page, click on the 1.1.x version listed there. This will take you to a Web page from which you can download JDK. The only item you need to download is the JDK software. Select the Solaris 2.4-2.6 SPARC platform. When you press the Continue button next to the platform selection, you will be shown a licensing agreement. Pressing Agree will take you to a selection between FTP download and HTTP download. There is a paragraph that helps you choose between these two methods. When you click one of these buttons, downloading begins.

When the 12 megabyte file has finished downloading, Java can be installed on any available disk. There are good installation instructions on the Web page. You can install Java wherever you want on your disks.

To run the TAI with your Java installation, edit the file $TRANSIMS_HOME/data/transims_cshrc to change the environment variable JAVA_HOME. JAVA_HOME should be set to the top directory where Java has been installed. The bin and lib directories in the Java distribution reside in this top directory.

In transims_cshrc:

```
setenv JAVA_HOME <directory where Java is installed>
```

For example,

```
setenv JAVA_HOME /usr/local/jdk1.1.5
```

6. INSTALLATION INFORMATION

The TRANSIMS V1.0 CDs come with everything you need to install and use TRANSIMS on the platforms for which TRANSIMS was developed.

Be sure to read the Hardware/Software requirements (Section 3) before attempting to install the CD-ROM disks to make sure that your system has the necessary hardware and software required to run TRANSIMS V1.0.

6.1 Deciding Where to Install

The TRANSIMS V1.0 system is set up to run from the directory /opt/transims. You may install TRANSIMS in this default directory, or you may choose another directory. This becomes your $TRANSIMS_HOME directory. Make sure there are NO capital letters in the installation directory name if you are planning on running the ArcView Input Editor as part of the TRANSIMS environment. ArcView is unable to handle capital letters in its paths.

The TRANSIMS environment and each user's home directory must be accessible by all machines on which the TAI and the microsimulation will run.

About 1.2 GBytes of space are needed to install TRANSIMS. This includes 250 MBytes for the TRANSIMS V1.0 environment and 946 MBytes for all calibration and Dallas-Ft. Worth Binary Plan Sets.

6.2 Installing the TRANSIMS Environment

Insert the TRANSIMS V1.0 Disk #1 CD into your CD-ROM device.

The Solaris system has volume management software that automatically mounts the CD-ROM for you. If this is not the case, please see your system administrator on how to mount the CD-ROM device.

The TRANSIMS CDs are accessed like any other UNIX file system. The TRANSIMS V1.0 environment is in the file transims1.tar. The UNIX tar utility was used to create this file. The Binary Plan Files are also compressed and exist in the BinaryPlans directory on Disk #1 in tar format.

TRANSIMS V1.0 takes about 1.2 GBytes of disk space once installed. This does not include any of the optional data files. The optional data files take additional space. See Section 6.6 for actual sizes of the optional data files.

If the installation directory does not exist, create it now. To install the TRANSIMS V1.0 environment, change directories to the installation directory (such as /opt/transims) then enter:

```
tar -xvBf /cdrom/cdrom0/transims1.tar
```

6.3 Installing the Binary Plan Files

The Binary Plan files are all in the BinaryPlans directory on the TRANSIMS V1.0 Disk #1. Run the script installBinaryPlanFiles, found on Disk #1, to install the binary plan files. Note: if you are not installing in the default location (/opt/transims), you must copy the installed Binary Plan Files script somewhere else and modify it for the proper installation location.

```
cd /cdrom/cdrom0
./installBinaryPlanFiles
```

6.4 Setting up for Microsimulation Data Collection

Each machine that runs the TRANSIMS Microsimulation must have local disk space available for microsimulation output. Each directory where the local output will be collected should be mounted and accessible from all machines where the microsimulation or the TAI will be run.

In addition, a symbolic link must be created in the $TRANSIMS_HOME/output directory to each of the mounted local output directories. The name of the symbolic links should be <machineName>1 for those machines with a single CPU and <machineName># for machines with several CPUs where the # is replaced by a number for each CPU.

After the links have been created, the file $TRANSIMS_HOME/data/TAI/machines.lis must be edited to add the hostnames of the machines and number of CPUs available on each machine.

Example for machine foo with four CPUs:

> Foo has four CPUs and four directories on foo's local disk where microsimulation output will be collected. These directories have been mounted as /home/FooOutput/foo1, /home/ FooOutput/foo2, /home/FooOutput/foo3, and /home/FooOutput/foo4.
>
> Four links in the $TRANSIMS_HOME/output directory must be created.

```
ln -s /home/FooOutput/foo1 $TRANSIMS_HOME/output/foo1
ln -s /home/FooOutput/foo2 $TRANSIMS_HOME/output/foo2
ln -s /home/FooOutput/foo3 $TRANSIMS_HOME/output/foo3
ln -s /home/FooOutput/foo4 $TRANSIMS_HOME/output/foo4
```

> The hostname of a machine is the output of the command /usr/bin/uname -n. It should be the name by which the machine is known to the communications network. The hostname for machine foo is foo.lanl.gov. Now, add the following entry to $TRANSIMS_HOME/data/TAI/machines.lis:

```
foo.lanl.gov 4
```

6.5 Gaining Access

Please note that all environment variables in this document will be discussed in terms of the C shell.

6.5.1 TRANSIMS Environment

Each user should have certain environment variables set in their .cshrc file. Variables needed are PATH, LD_LIBRARY_PATH, MANPATH, and DISPLAY. If PATH, LD_LIBRARY_PATH, and MANPATH are not defined, they are set to defaults by a TRANSIMS script. The DISPLAY environment variable must be set within the user's own .cshrc file.

All run-time environment variables needed to run TRANSIMS are located in a special TRANSIMS file. To incorporate these variables into the users' environment, the following lines must be created at the bottom of each user's .cshrc file:

```
setenv TRANSIMS_HOME /opt/transims
source $TRANSIMS_HOME/data/transims_cshrc
```

If TRANSIMS has been installed in a different location, replace the /opt/transims in the line above with the proper location.

6.5.2 OpenWindows and the Microsimulation Output Viewer

There is a known OpenWindows server bug that hangs the console when the mouse focus style is not "followmouse." Users should add the following line to their .Xdefaults before starting OpenWindows:

```
OpenWindows.SetInput:followmouse
```

6.5.3 PVM

The PVM being used with TRANSIMS requires that there are no query statements within a user's .cshrc file. Remove these types of statements, exit the window manager, and reenter the window manager before starting up TRANSIMS.

6.5.4 Java

Java must be installed on your system. Java is supplied with Solaris 2.6 in /usr/java1. See Section 5 for information on how to install Java if using earlier versions of Solaris 2. Modify the $TRANSIMS_HOME/data/transims_cshrc file for proper location of your particular version of Java.

6.5.5 Running ArcView

If you have ArcView and plan to use it in the TAI, you must execute the following:

```
cd
ln -s $TRANSIMS_HOME/data/ined/default.apr
```

6.5.6 Links to Data

If you plan to access any of the ASCII Plan Sets, $TRANSIMS_HOME/data/PLANS/Ascii has been set up to contain these optional files, or links can be made in that directory to the actual data files. See Section 6.6.1.1 for more information about ASCII Plan Sets.

6.5.7 Files to be Modified

If TRANSIMS V1.0 was not installed in /opt/transims, you will need to run the script modifyHome on the TRANSIMS V1.0 Disk #1. This will replace all of the /opt/transims strings in the TRANSIMS environment with the appropriate installation directory.

```
cd /cdrom/cdrom0
./modifyHome
```

Modifying $TRANSIMS_HOME/data/TAI/machines.lis

You must list all machines that have a symbolic link in the distributed output directory $TRANSIMS_HOME/output and after the machine name, the number of CPUs on that machine. All machines where the microsimulation will be run must have an entry in this file. Entry format:

<hostname> <number of cpus>

Modifying $TRANSIMS_HOME/data/TAI/rhosts

You must list the host names of all machines from which a user is able to run the TAI and all machines from which the Microsimulation may run.

$TRANSIMS_HOME/data/transims_cshrc must be edited to set OPENWINHOME, XGL_HOME, MOTIF_HOME, ARCVIEW_HOME, and JAVA_HOME for your system setup. ARCVIEW_HOME is optional.

If you are planning to compile any of the TRANSIMS V1.0 systems, the file $TRANSIMS_HOME/source/Makefile.sunos5 must be modified if the Booch components are not installed under /usr/booch.

6.5.8 File Permissions

All users of TRANSIMS V1.0 must be in the same group (have the same groupid) in order to access any of the database tables and in order to run various TRANSIMS components.

It is suggested that users set their umask as 002 (group writeable) in their .cshrc files.

Change group and ownership on all necessary files to be owned by someone within the group. To do this, copy the disk #1 file modifyFilePermissions to a temporary location. Edit the file to set the new group name and a new user name. Run the modified script.

Note: This must be done after the modifyHome script is run from the previous section!

6.6 Installing Optional Data

TRANSIMS V1.0 Disk #2 contains the plans used to run the Dallas-Ft. Worth Case Study runs and the Microsimulation output from those runs. To access this data, mount the TRANSIMS V1.0 Disk #2 CD. Data for each Dallas-Ft. Worth Case Study run is in a separate directory on the CD. Change directory to the desired subdirectory. For example:

```
cd /cdrom/cdrom0/nctcog-basecase-1-1
```

6.6.1 Data Available

6.6.1.1 ASCII Plan Sets

The following Dallas-Ft. Worth Case Study ASCII Plan Sets are available:

- case study 1 base case 1 - nctcog-basecase-1-1-plans.txt.Z
- case study 1 base case 2 - nctcog-basecase-1-2-plans.txt.Z
- case study 1 infrastructure change 1 - nctcog-change1-1-1-plans.txt.Z
- case study 1 infrastructure change 2 - nctcog-change2-1-1-plans.txt.Z

Each plan set is about 80 MBytes compressed or 250 MBytes uncompressed. The data is in a compressed format on the CD and must be uncompressed onto your local system to access. For example, to access the base case 1 Plan Set, enter:

```
cd /cdrom/cdrom0/nctcog-basecase-1-1
cat nctcog-basecase-1-1-plans.txt.Z | uncompress > \
$TRANSIMS_HOME/data/PLANS/Ascii/nctcog-basecase-1-1-plans.txt
```

Plan Sets have been converted to binary for microsimulation runs and are located on the TRANSIMS V1.0 Disk #1. Therefore, access to the ASCII versions is not necessary in order to run the Microsimulation. If the ASCII versions are installed, they must be located in the $TRANSIMS_HOME/data/PLANS/Ascii directory (or at least a link to them). The files, or links, must be named the same as is expected in the $TRANSIMS_HOME/data/TAI/ *pln files after the key word *FortranPlanFile*.

Dallas-Ft. Worth Plan Sets have also been converted for Plan Viewer viewing, but only 10 percent of the plans for each network are in PlanViewer plan format. If a different percentage is desired, the ASCII files will be needed.

6.6.1.2 Microsimulation Output

The following Dallas-Ft. Worth Case Study Microsimulation Output is available:

- base case 1 - full, Non-Galleria, Galleria-only
- base case 2 - full
- infrastructure change 1 - full, Non-Galleria, Galleria-only

- infrastructure change 2 - full, Non-Galleria, Galleria-only

Microsimulation output data is stored by network. The entire directory for each network has been compressed and archived into a tar file. To get the data for a particular run, enter lines similar to the following:

```
cd <localPath>
mkdir nctcog-basecase-1-1
cd <localPath>/nctcog-basecase-1-1
cat /cdrom/cdrom0/nctcog-basecase-1-1/MicrosimOutput.tar.Z | uncompress | tar -xvBf -
```

Each network's directory is a different size. Table 2 shows the sizes of each of the four directories, both compressed and uncompressed.

Table 2: Network directory sizes

Compressed	Uncompressed	
Base Case 1 Output	71 MB	387 MB
Base Case 2 Output	30 MB	149 MB
Change 1 Output	72 MB	383 MB
Change 2 Output	61 MB	320 MB